



# **Status of the HALOE Algorithm and Data Set**

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**by**

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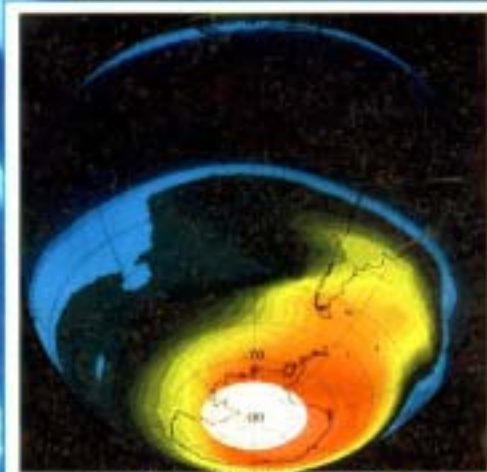
**Larry L. Gordley, R. Earl Thompson and Marty McHugh  
GATS, INC., Newport News, Virginia USA**

**John G. Wells and Ellis E. Remsberg  
NASA Langley Research Center**



# HALOE MISSION

Orbiting the earth on UARS since September, 1991, HALOE measures Ozone, key trace gases (HF, HCl,  $\text{CH}_4$ , NO,  $\text{NO}_2$ , and  $\text{H}_2\text{O}$ ), temperature, and aerosols. Results are providing significant findings on the chemistry and dynamics of the earth's atmosphere (10-140 km).

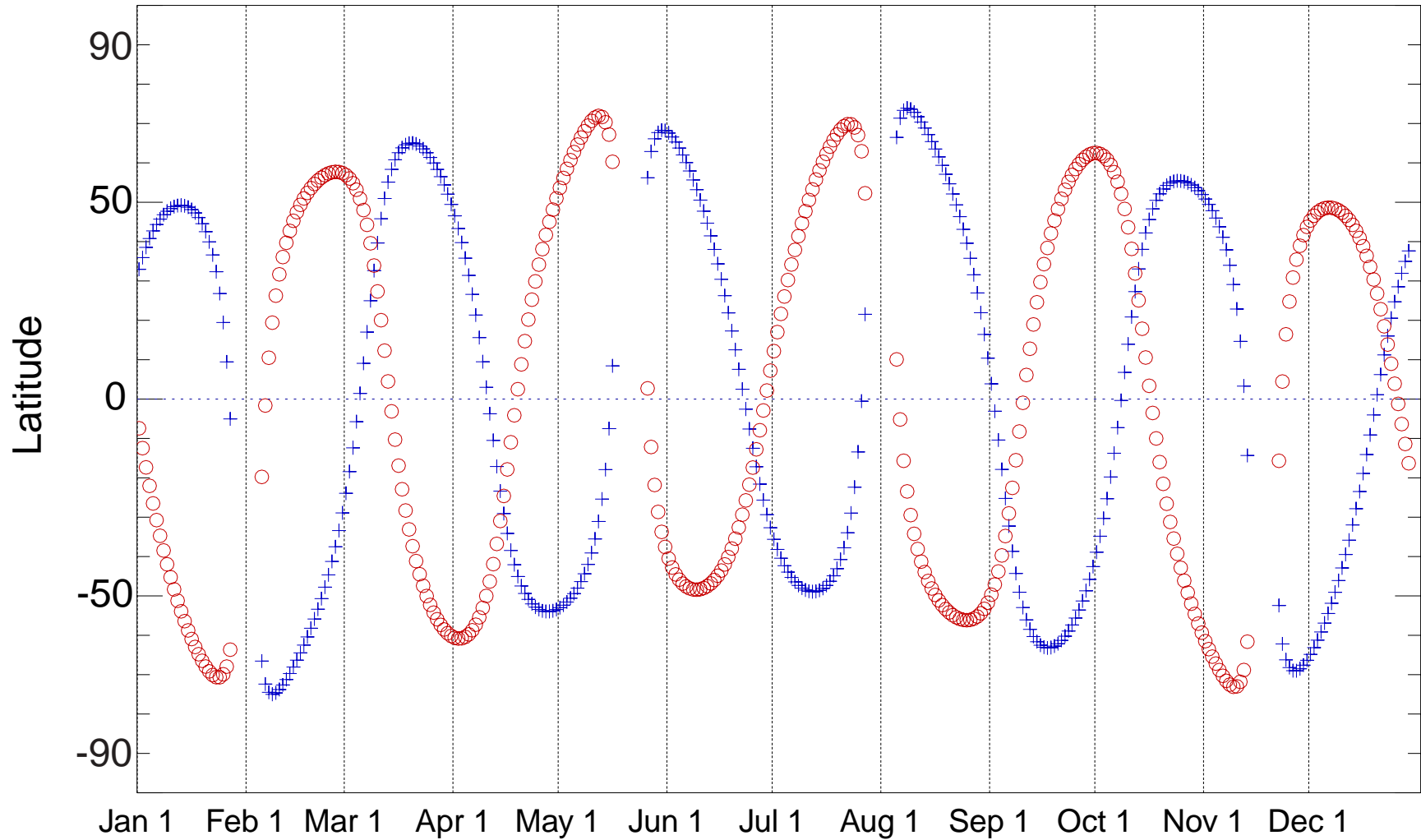


HF Orthographic Projection  
During 1992 Antarctic Spring



# HALOE ideal latitude versus time coverage for 1999.

Actual coverage is reduced due to UARS duty cycling





# HALOE Experiment Status

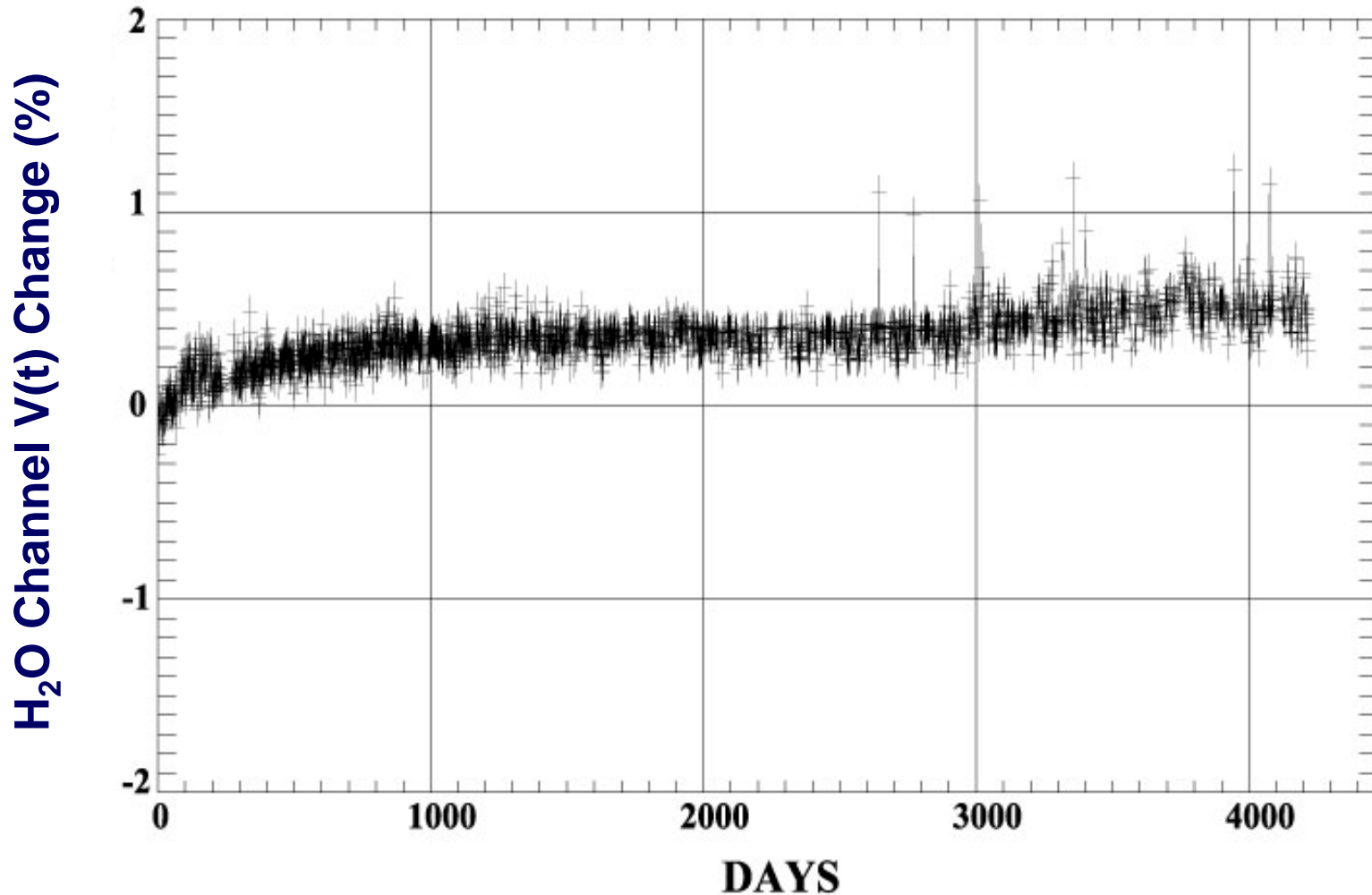
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- Experiment is in 12<sup>th</sup> year of data collection; ~ 3,000 days, ~ 82,000 events processed
- Instrument continues to operate essentially without flaw
- Maximum change in exoatmoapheric voltage over the life mission is  $\leq 2.5\%$  in worst case channel; some channels show  $\leq \sim 0.5\%$ ; demonstrates excellent signal stability
- On-orbit checks of electronic gains used in retrievals shows they are very stable
- Channel voltage versus temperature slope trends indicate stable infrared filters
- Sun sensor voltage has decreased by only ~ 25% leaving thereby still providing large signal-to-noise

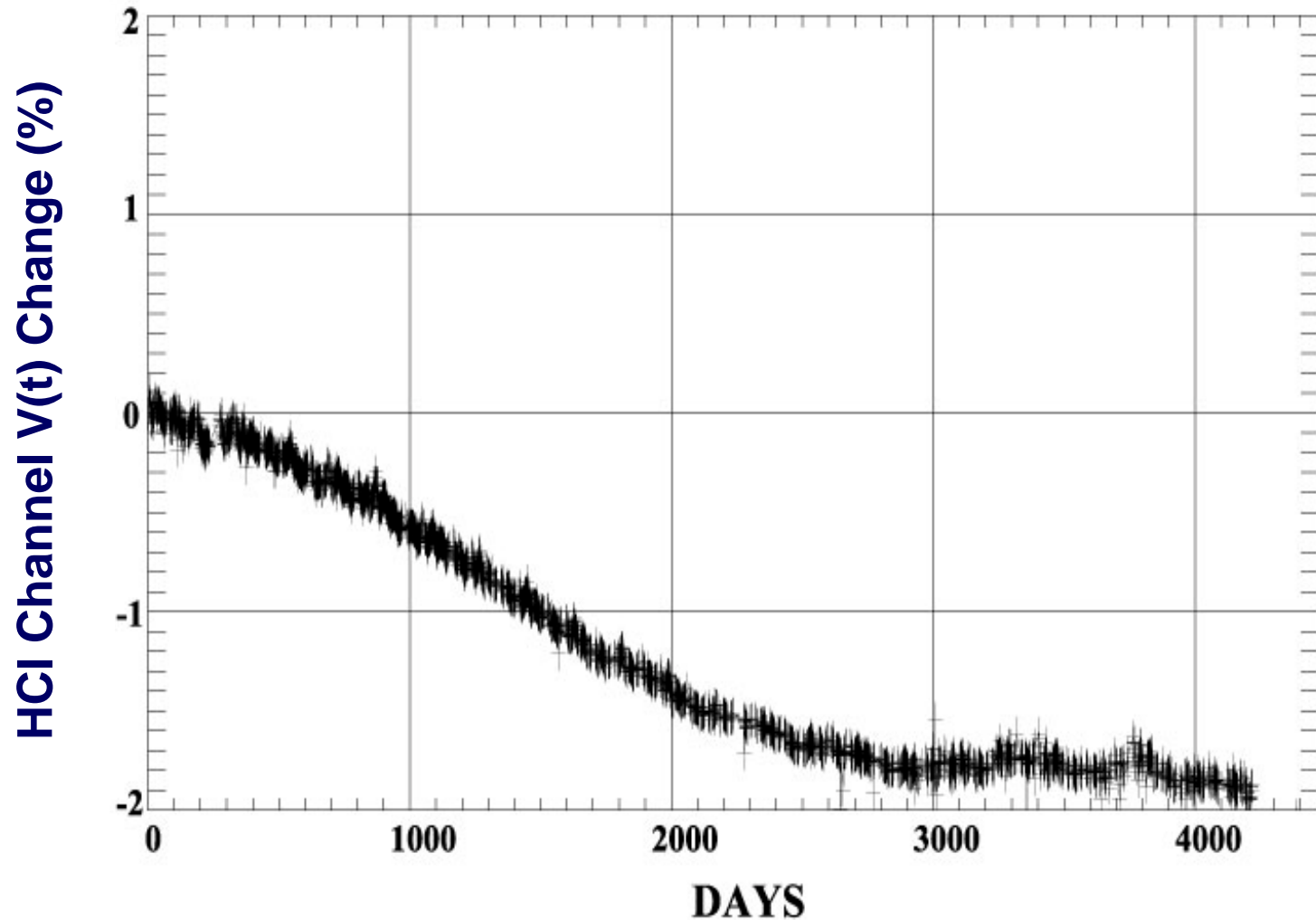


# HALOE absolute H<sub>2</sub>O channel peak voltage (%) $\Delta$ Versus time for October 11, 1991 to December 31, 2002





# HALOE absolute HCl channel peak voltage (%) $\Delta$ Versus time for October 11, 1991 to December 31, 2002





# UARS STATUS

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- **UARS engineering team doing outstanding job to keep mission operational; operations by Capital University**
- **Fixed solar array**
- **2 of 3 battery banks operational (limits low beta operations)**
- **1 of 2 tape recorders operational – two hours record time (uses one side of tape– operates at 2X normal speed)**
  - **TDRS contacts provide bulk of data for most instruments and 50% of HALOE occultation events when HALOE is operational**
  - **Tape recorder is dedicated to HALOE to capture an additional 40- 45% of HALOE events when HALOE is operational**
  - **80% of all HALOE data currently being collected by UARS**

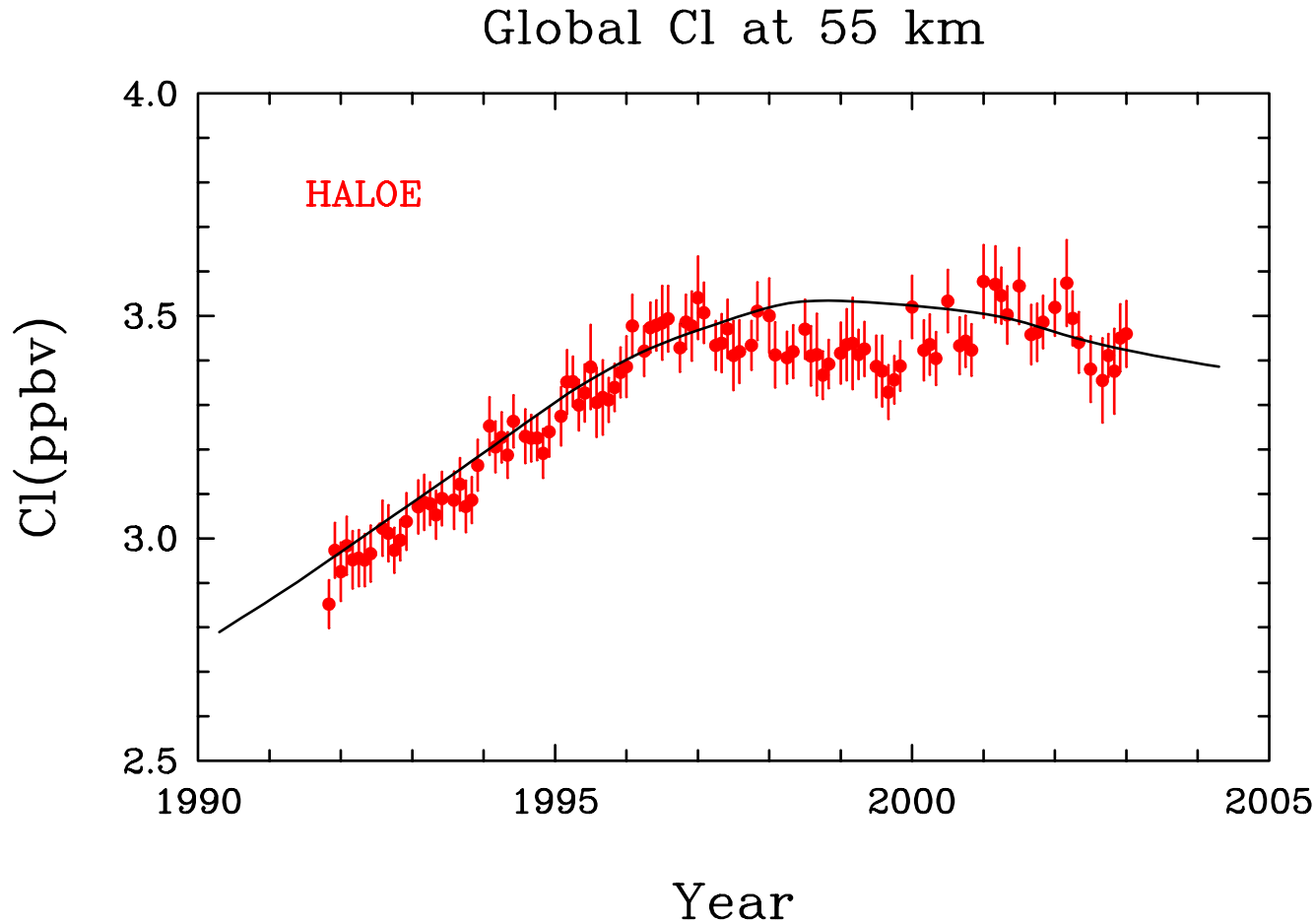


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## **HALOE Long-term Change Data**



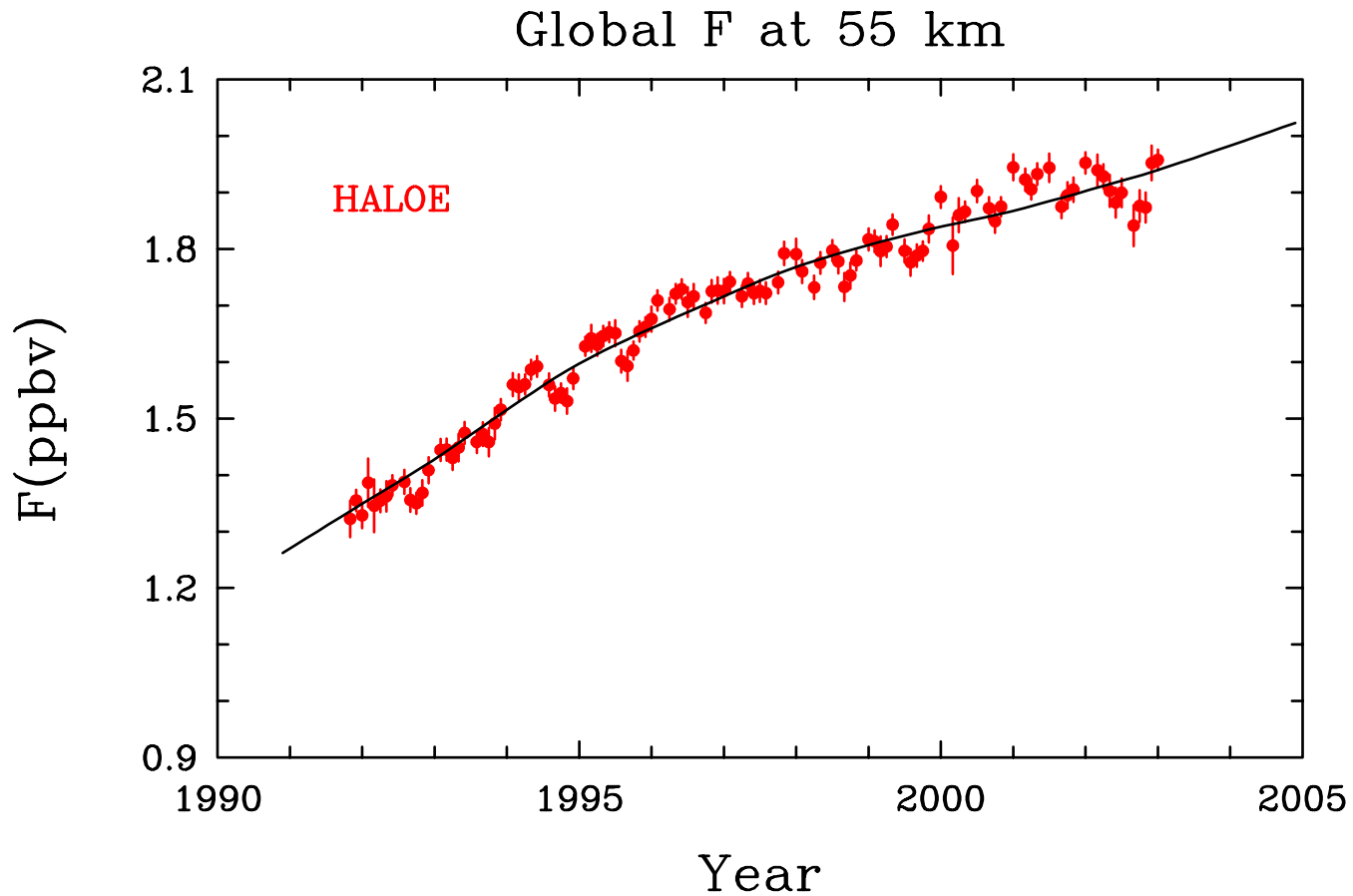
# HALOE derived inorganic Cl and the WMO(1998) baseline scenario



**WMO CCl<sub>y</sub> (black line) at the ground is shifted forward 5.3 years to account for the lag time.**



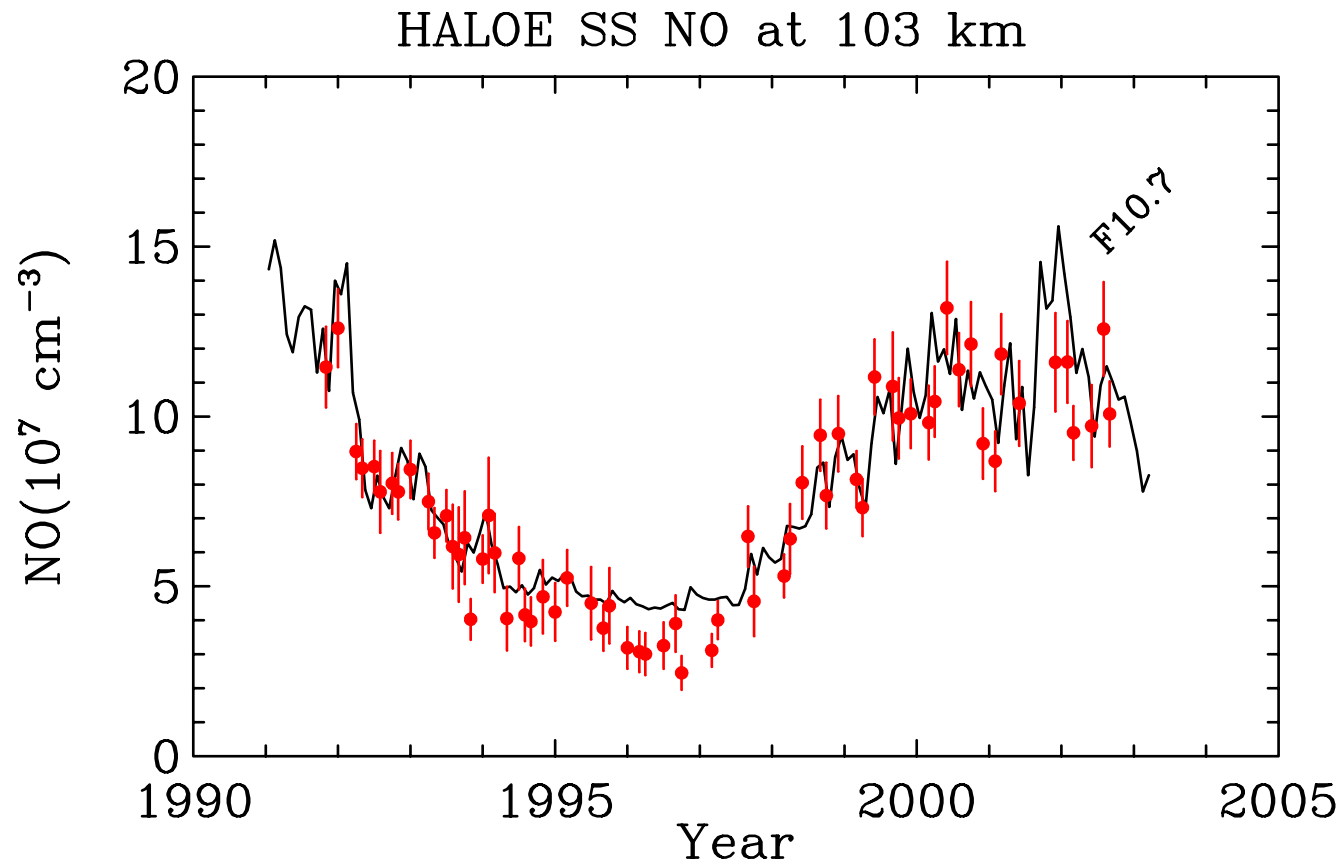
# HALOE derived inorganic F and the WMO(1998) baseline scenario



**WMO CF<sub>y</sub> (black line) at the ground is shifted forward 4.7 years to account for the lag time.**

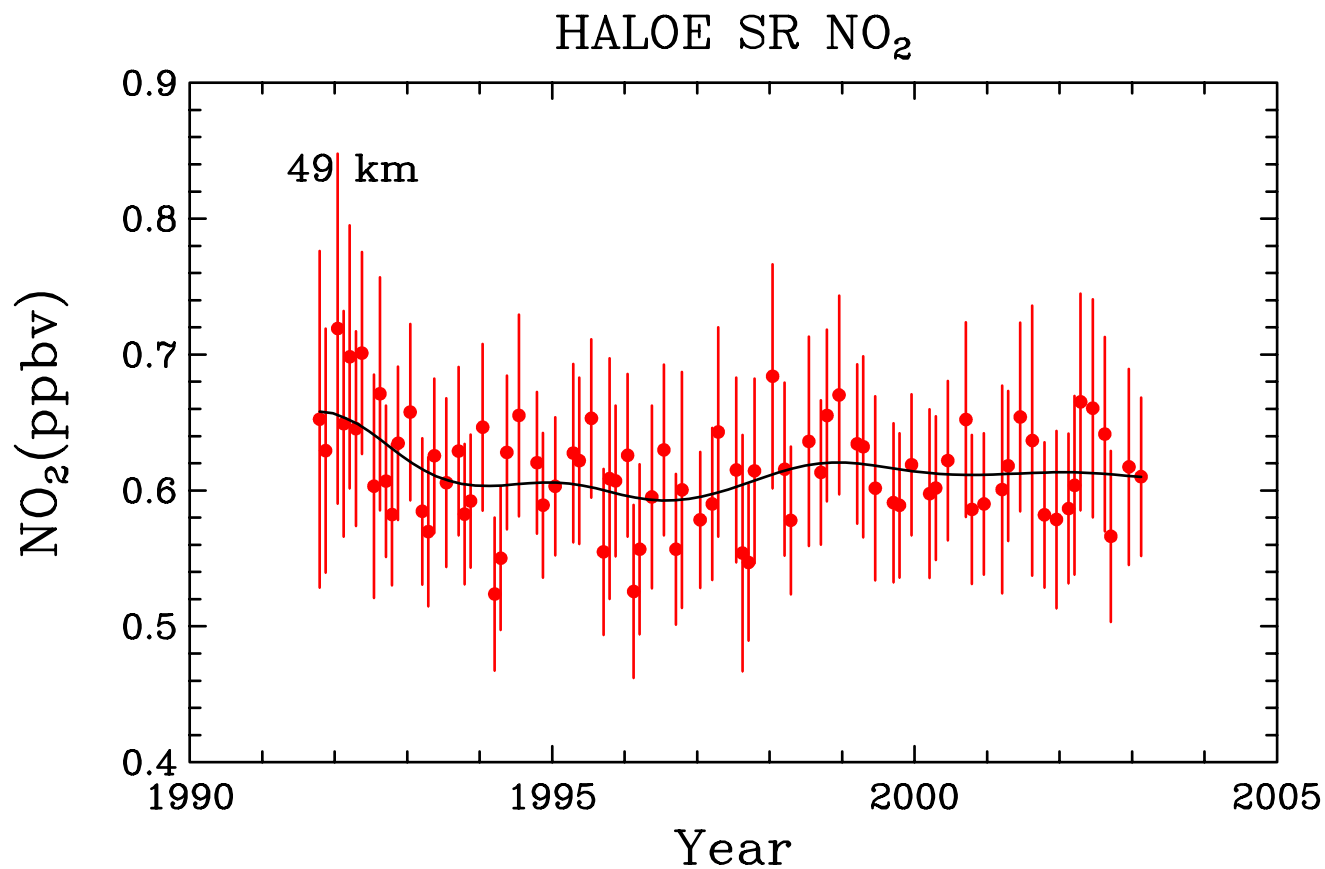


## HALOE NO time series and the F10.7 CM Flux



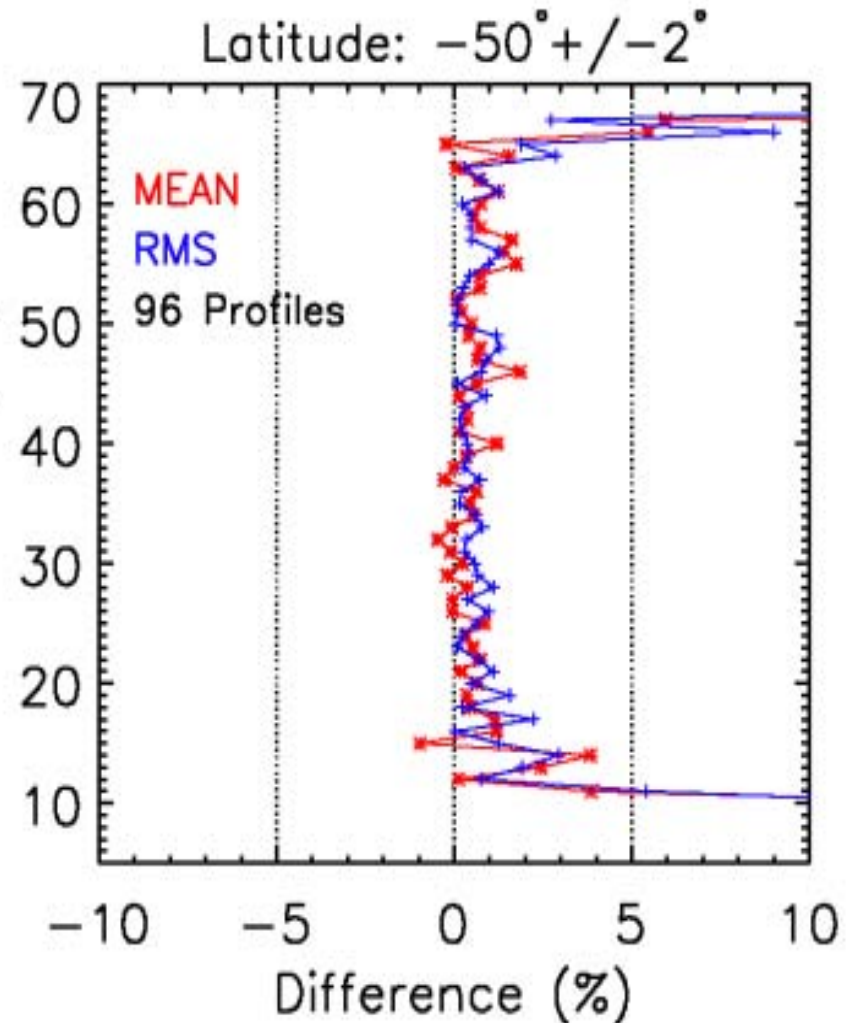
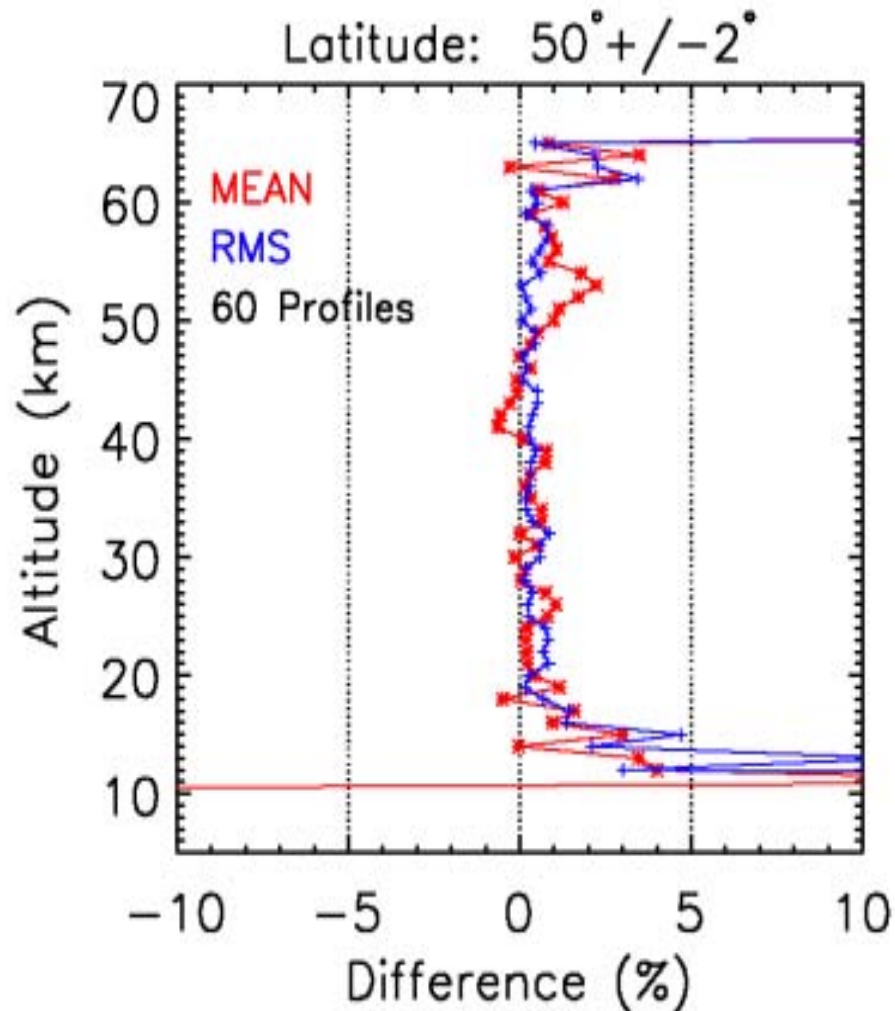


# HALOE NO<sub>2</sub> SR time series



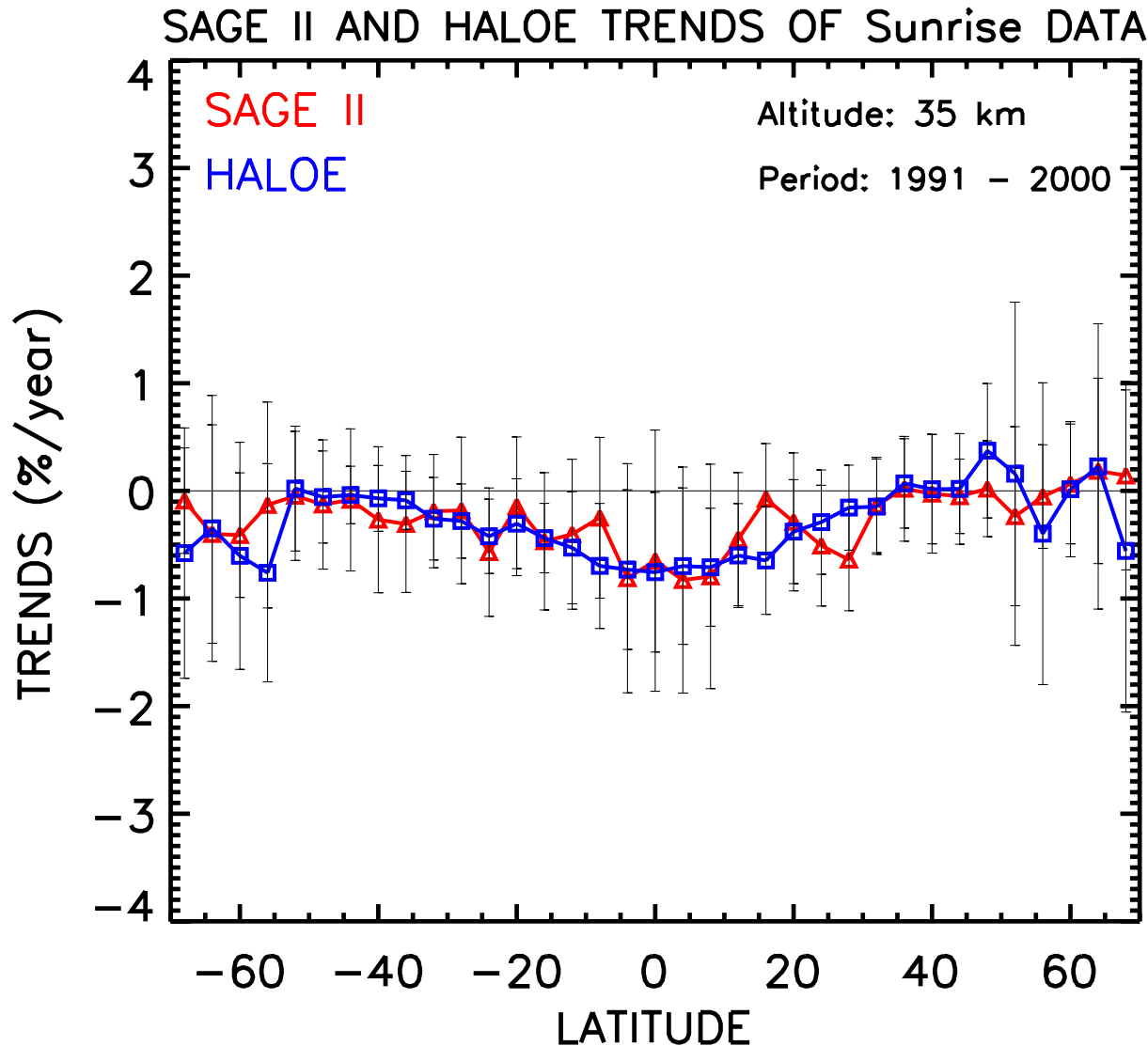


# PERCENT DIFFERENCE BETWEEN SAGE II AND HALOE (For the Period 1991 - 2002)



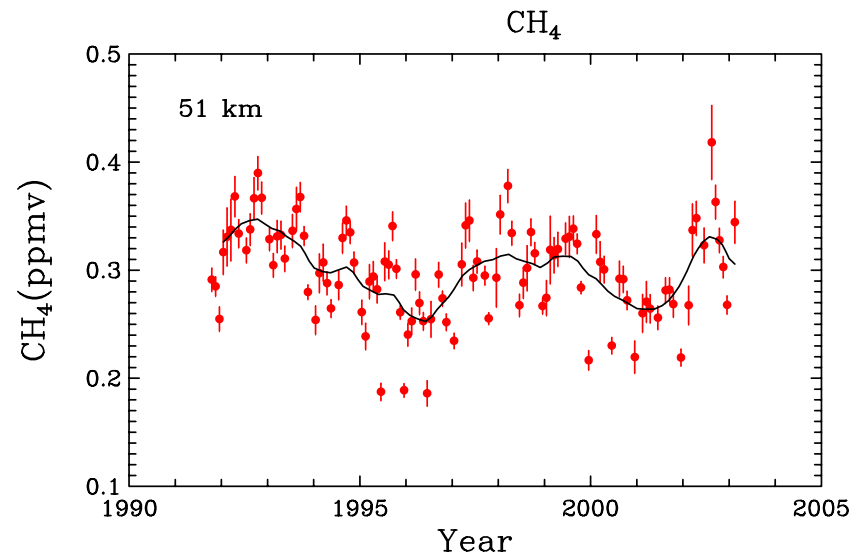
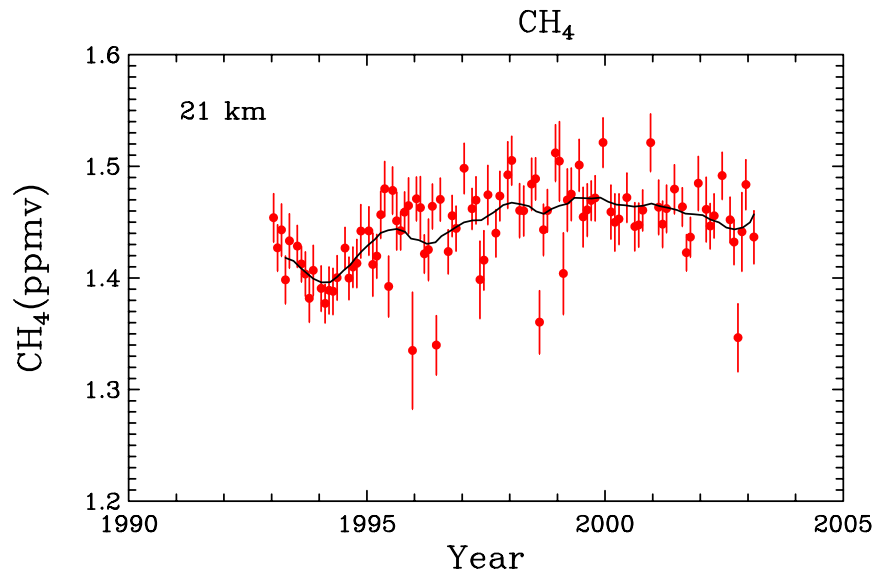
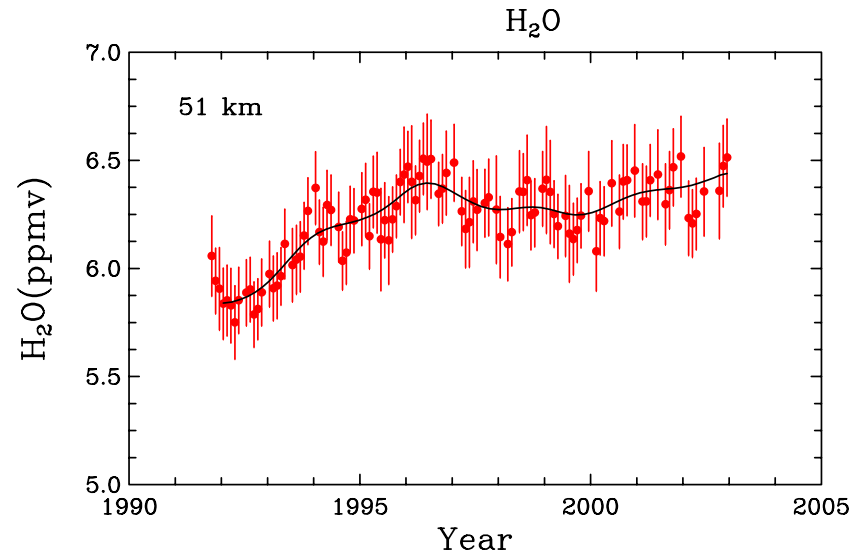
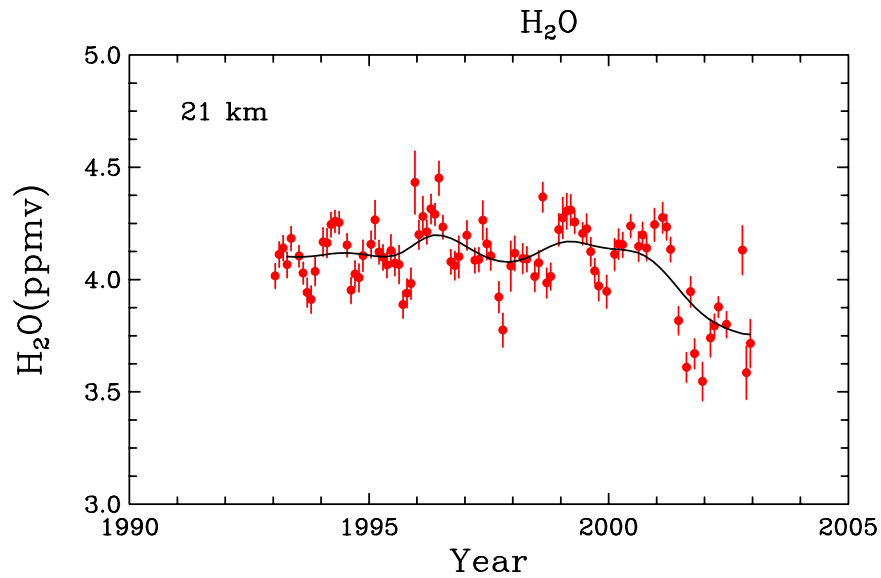


# Comparison of HALOE and SAGE II Trends for the period 1991 to 2000





# HALOE H<sub>2</sub>O and CH<sub>4</sub> time series at 21 km and 51 km







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# **HALOE 4<sup>th</sup> Public Release (V20) Data Processing**



## HALOE V20 4<sup>th</sup> Public Release Enhancements

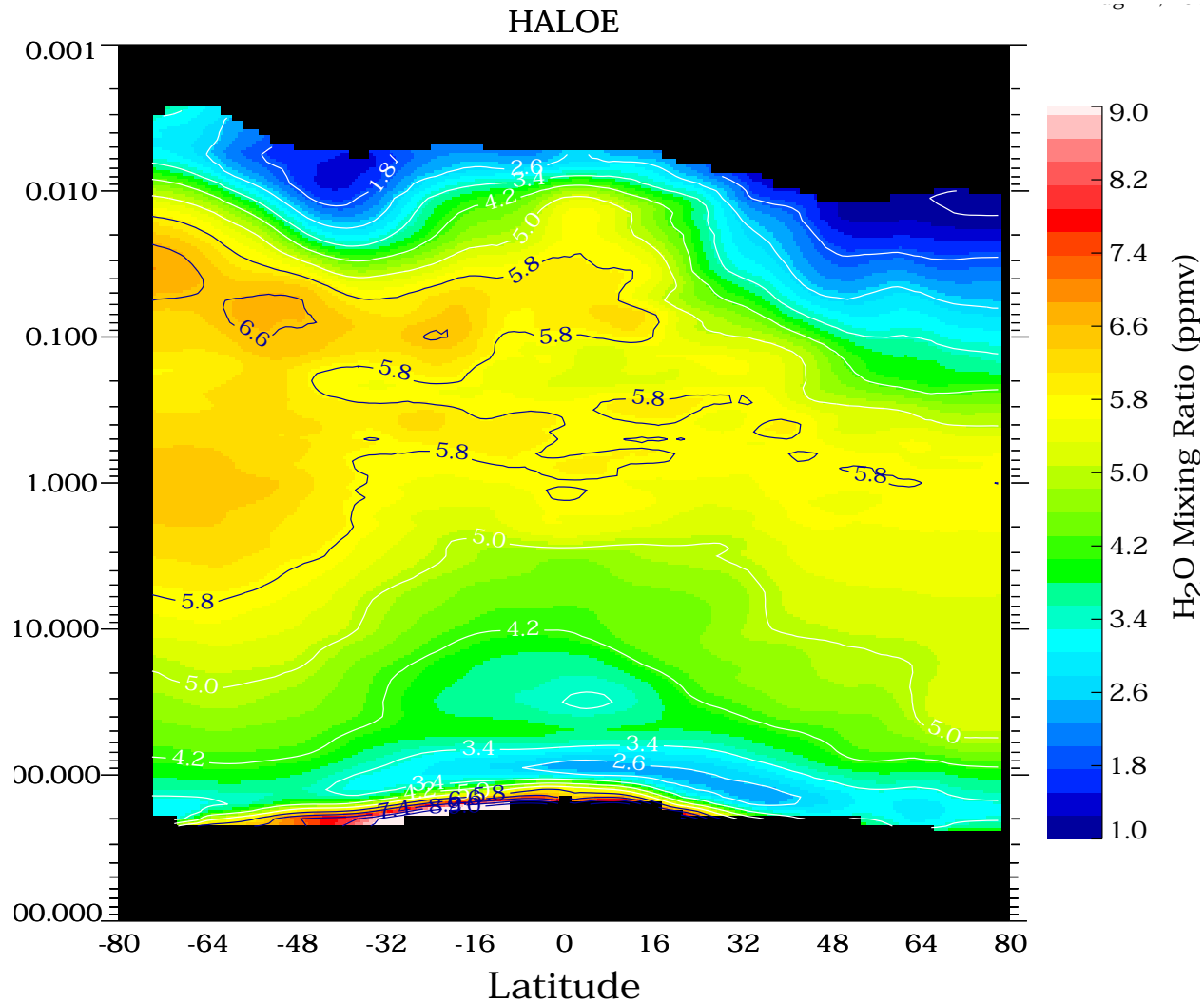
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- **New product:** Continuous H<sub>2</sub>O profiles from mid-troposphere to mesopause
- **New product:** Cloud height
- **New products:** Higher vertical resolution HCl, HF, CH<sub>4</sub>, NO (2.5 km versus 4 km)
- **Higher accuracy for:**
  - O<sub>3</sub> in lower stratosphere / upper troposphere
  - Tropopause height
  - Aerosol obtained from the HCl and NO channels
  - Radiometer aerosol corrections
- Improved fidelity in NO<sub>2</sub>, O<sub>3</sub> and HF vertical profiles

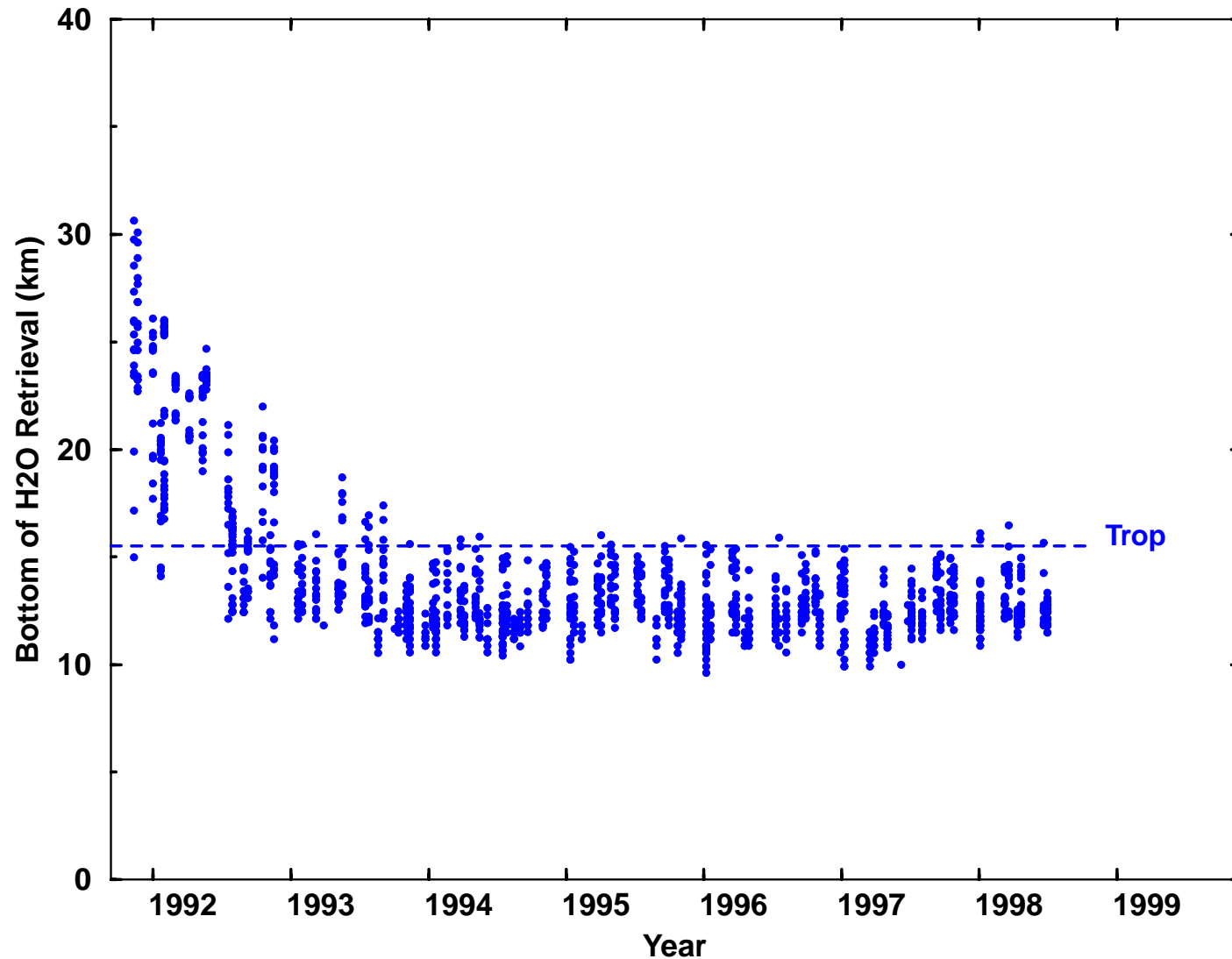


# HALOE H<sub>2</sub>O pressure versus latitude cross section for the period March 5, 1993 to April 11, 1993



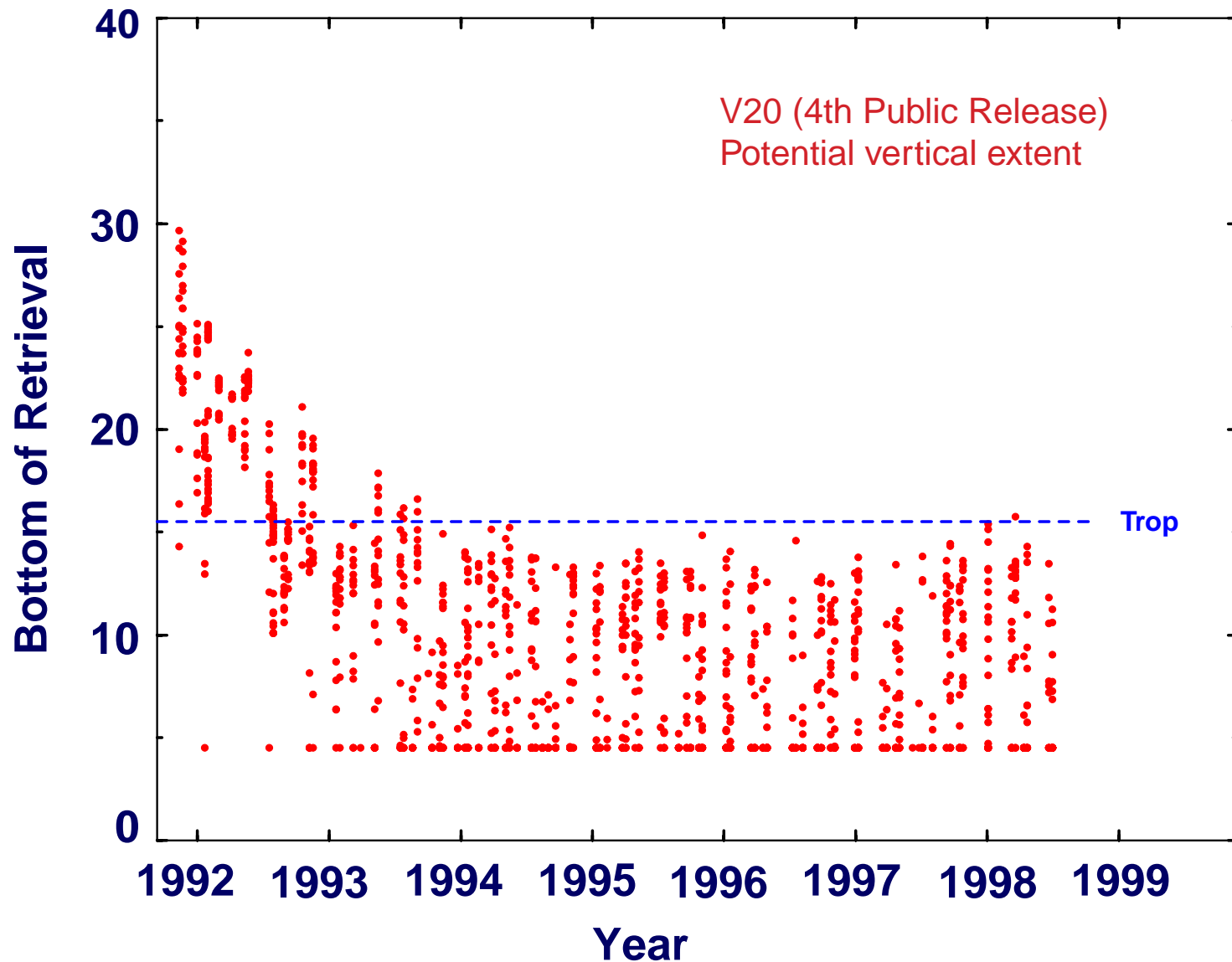


# HALOE H<sub>2</sub>O V19 (3<sup>rd</sup> Public Release) vertical extent in the tropics | Latitude| < 30°; Profiles from every 10th day





# H2O V20 (to be 4<sup>th</sup> Public Release) vertical extent, tropics, | Latitude | < 30° ; Profiles from every 10th day





# HALOE H<sub>2</sub>O Upper Troposphere Data Processing Approach

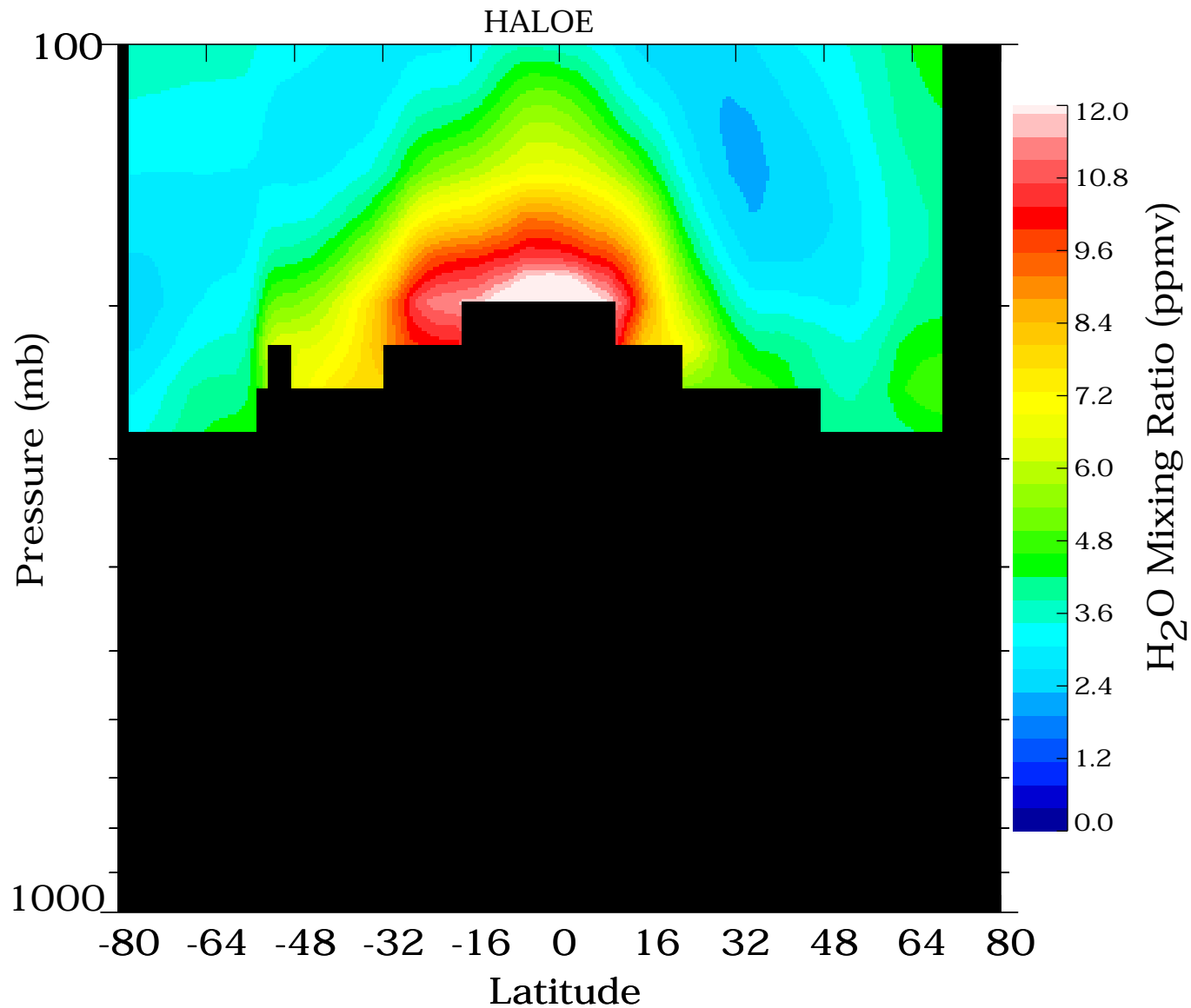


- The standard approach is retrieving on  $\tau_{\text{H}_2\text{O}}$  at 6.3  $\mu\text{m}$
- Retrieving H<sub>2</sub>O using  $\tau_{\text{HF}}$  at 2.45  $\mu\text{m}$  gives improved atmospheric sensitivity via weak H<sub>2</sub>O absorption lines
- Retrieving using the HF gas filter signal gives much better instrument sensitivity (by ~ 30X)
- Using the gas filter approach in the troposphere reduces sensitivity to pointing errors and aerosol / cirrus absorption

$$\Delta S \propto \frac{\tau_{\text{H}_2\text{O}} \tau_{\text{Aer}} \tau_{\text{Cirrus}} \tau_{\text{gas cell}} - G \tau_{\text{H}_2\text{O}} \tau_{\text{Aer}} \tau_{\text{Cirrus}}}{\tau_{\text{H}_2\text{O}} \tau_{\text{Aer}} \tau_{\text{Cirrus}}}$$

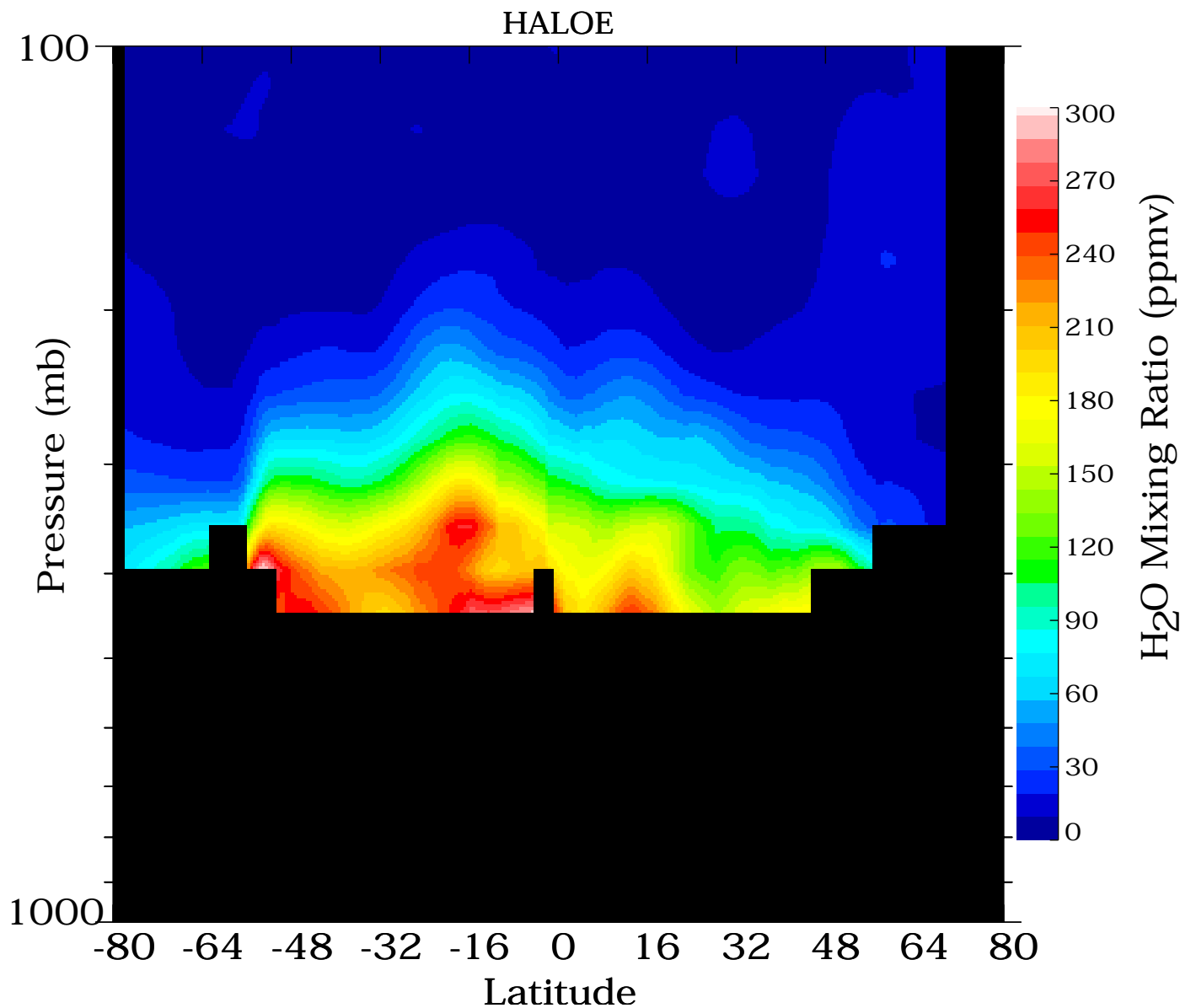


# H<sub>2</sub>O V19 (3<sup>rd</sup> Public Release) pressure versus latitude Cross Section, Sunset February 16 to March 27, 1997



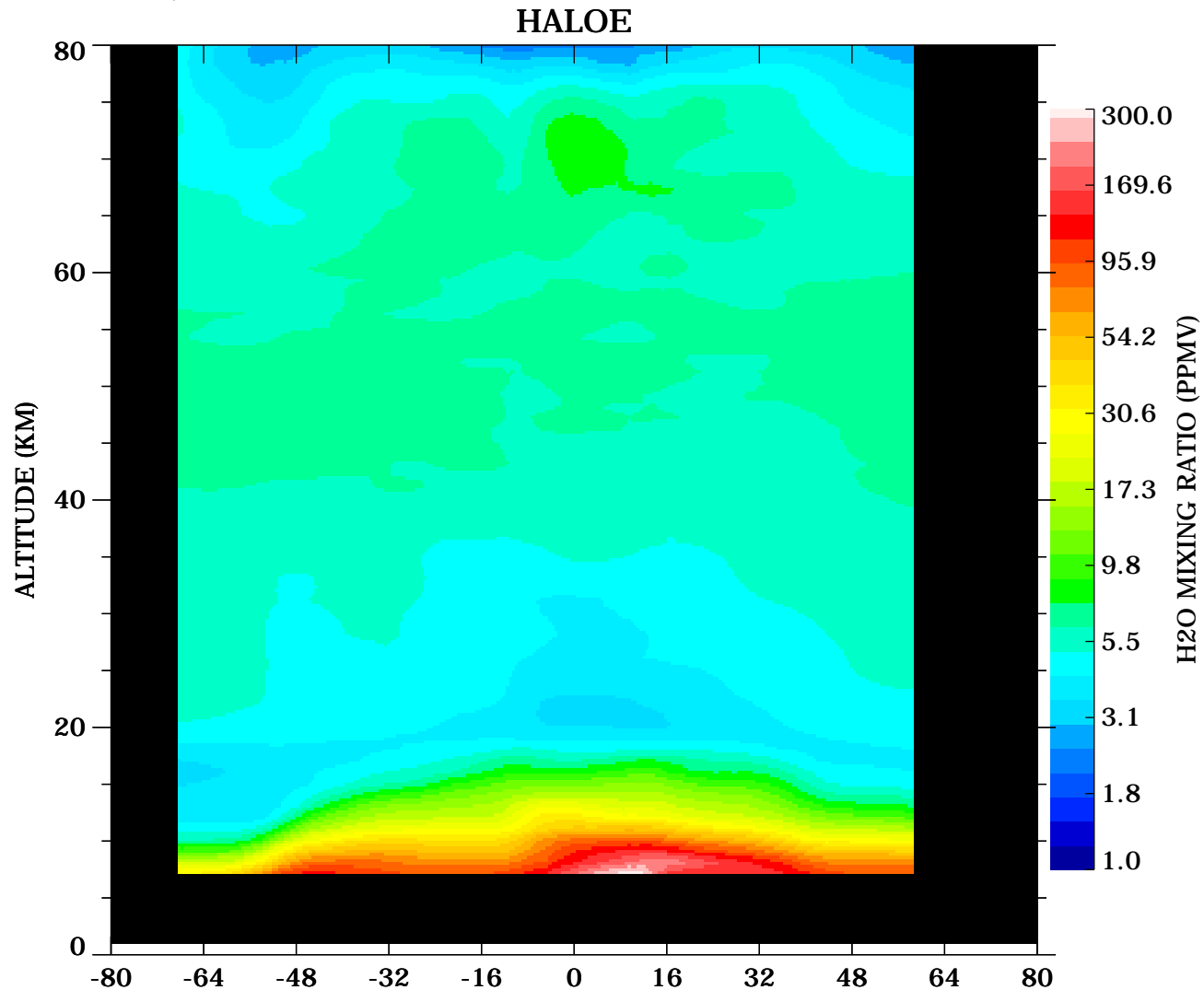


# H2O V20 (to be 4<sup>th</sup> Public Release) pressure versus latitude Cross Section, SS February 16 to Mar 27, 1997



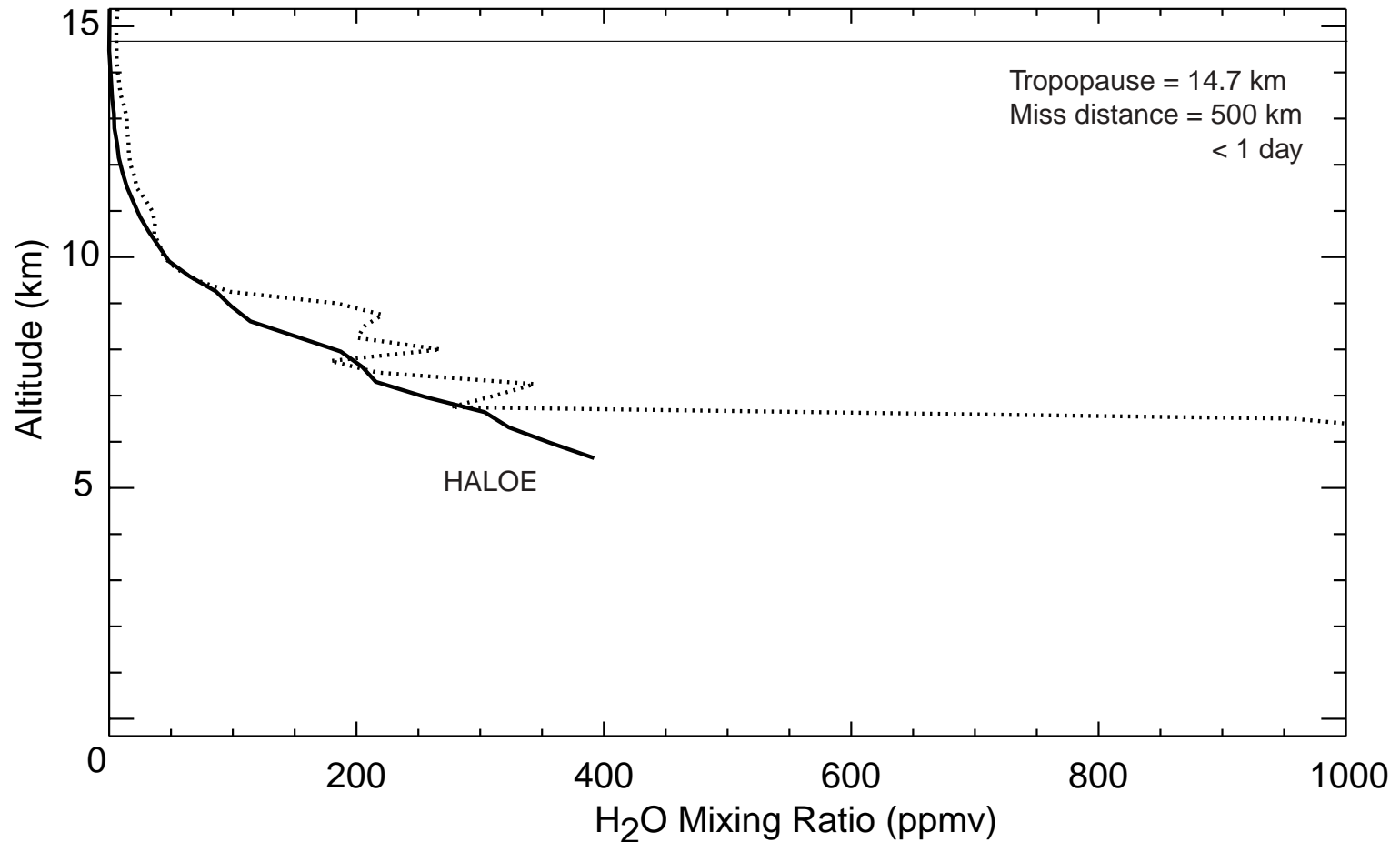


# H2O V20 latitude cross section, September 18 to November 26, 1995; Extends from ~6 km to 80 km.





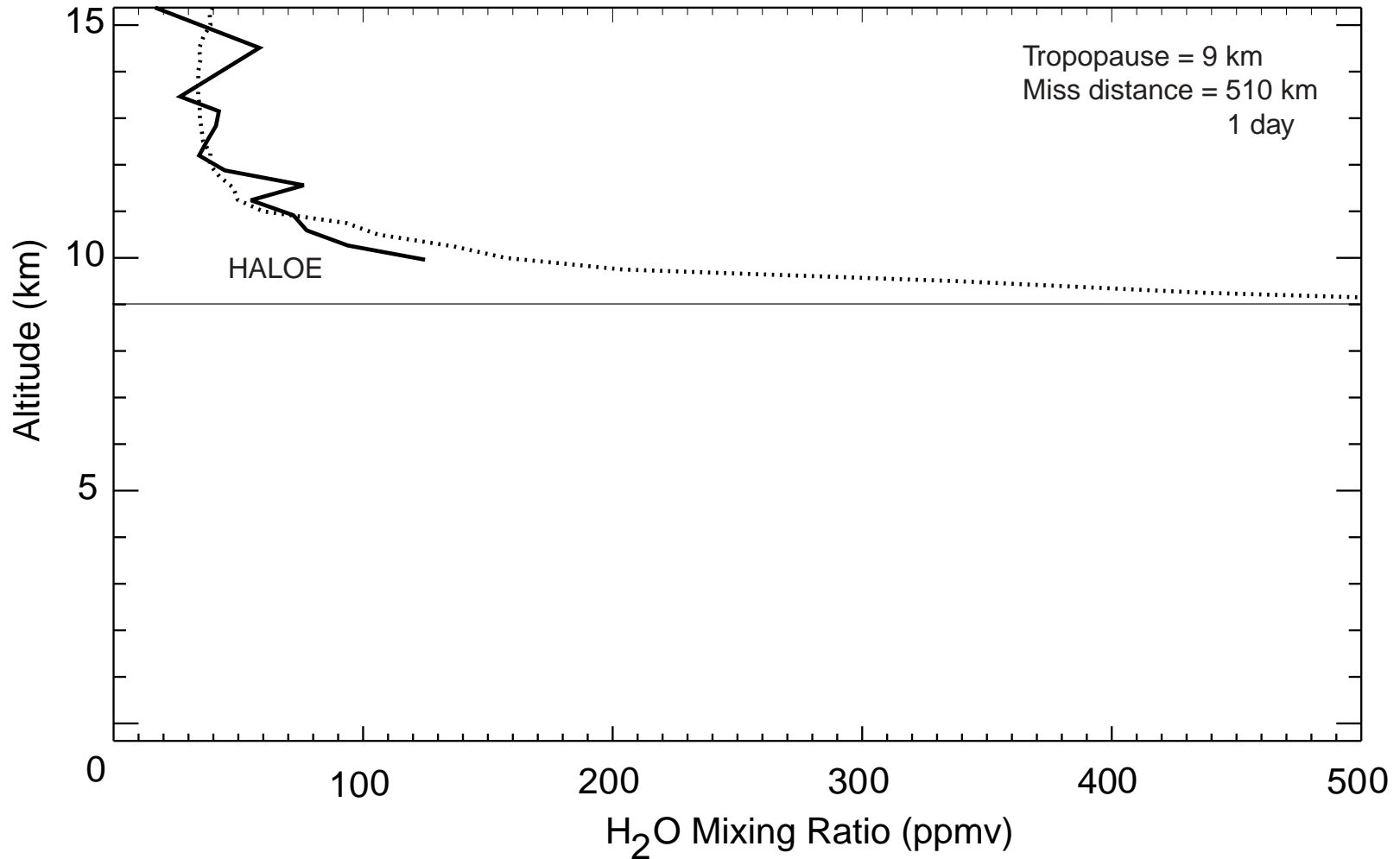
# HALOE upper tropospheric $\text{H}_2\text{O}$ compared with balloon frostpoint hygrometer data 40°N, December 3, 1998



(Balloon data, Oltmans, private communication, 2000)



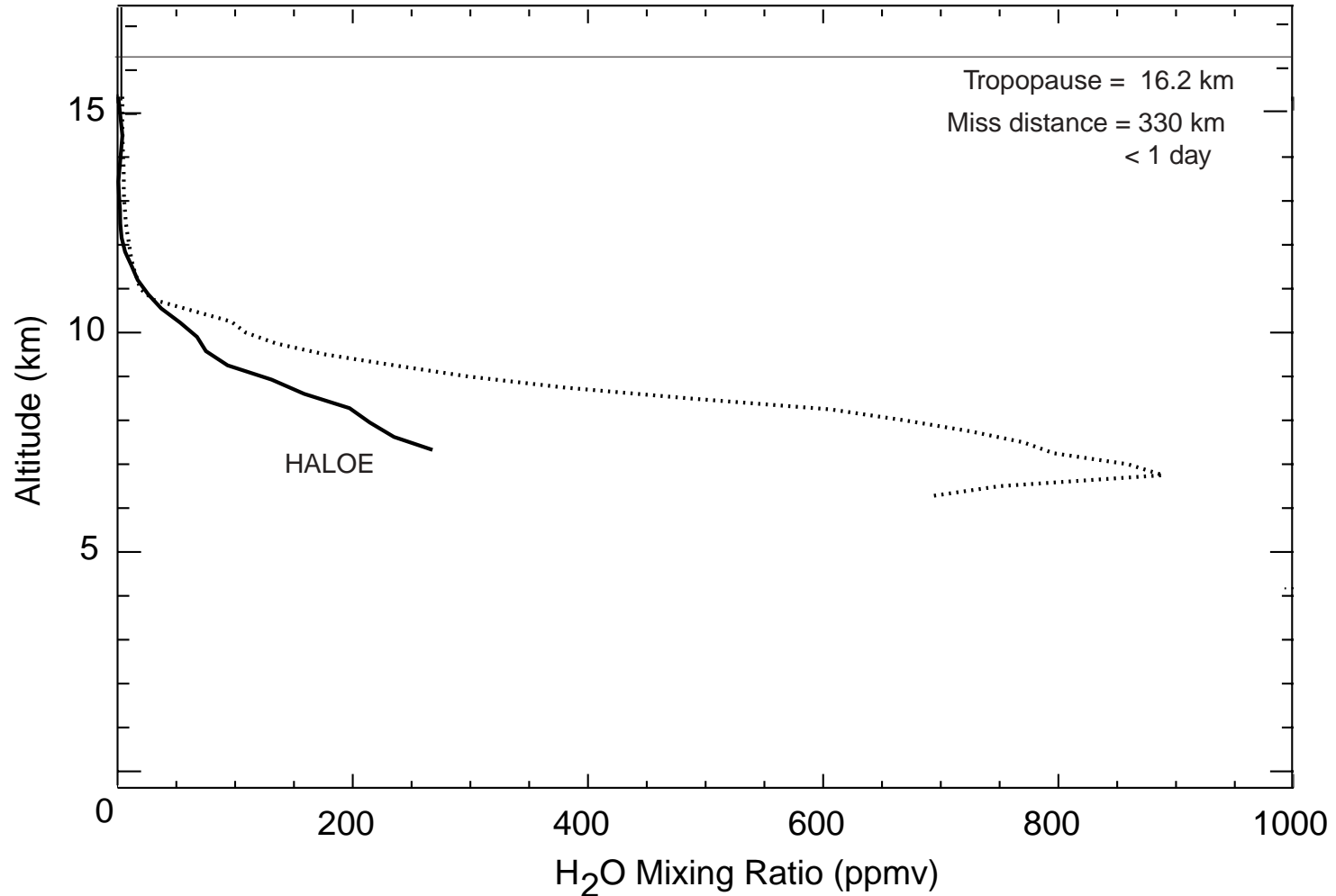
# HALOE upper tropospheric $\text{H}_2\text{O}$ compared with balloon frostpoint hygrometer data, 40°N January 20, 1999



(Balloon data, Oltmans, private communication, 2000)



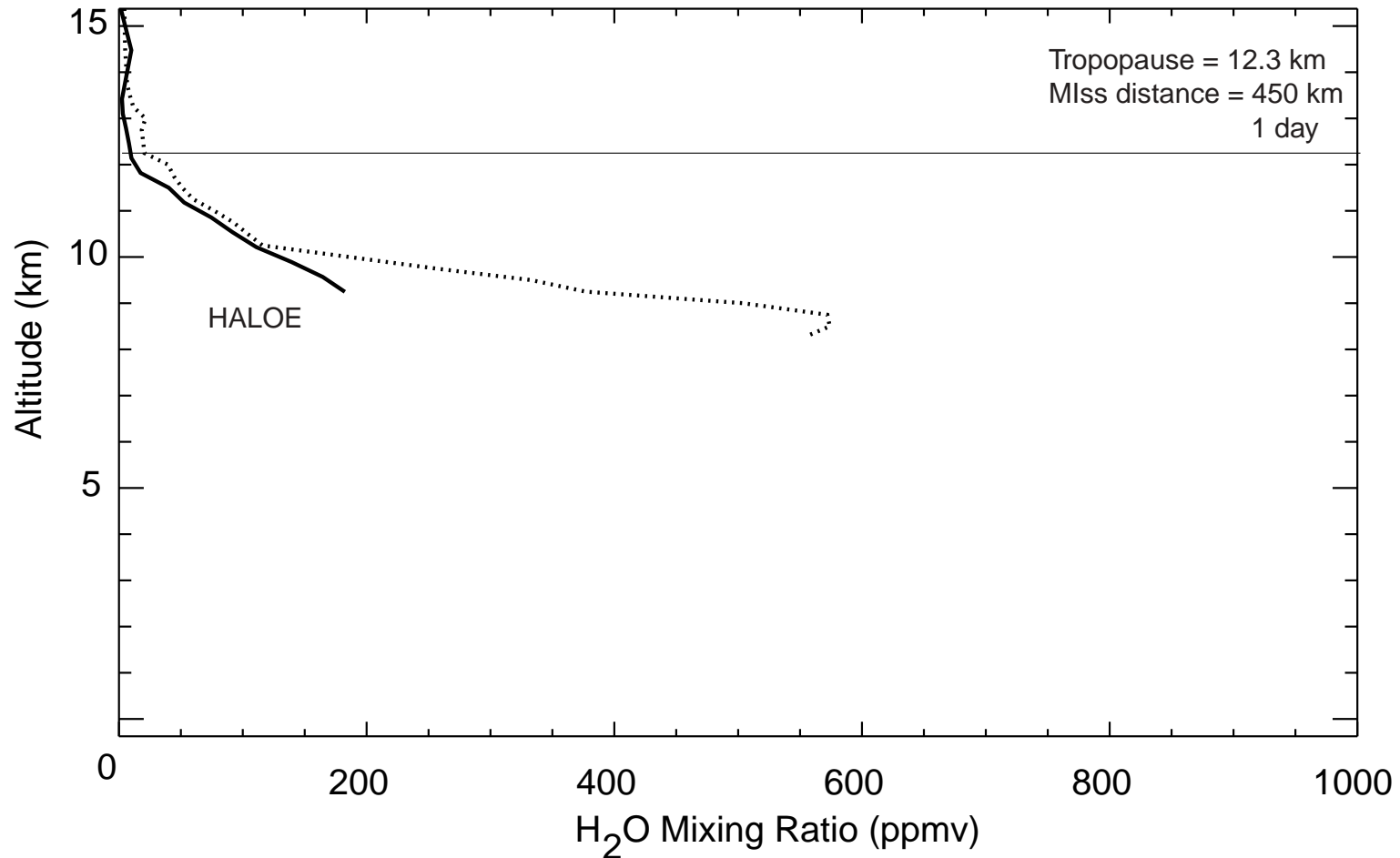
# HALOE upper tropospheric $\text{H}_2\text{O}$ compared with balloon frostpoint hygrometer data, 40°N October 24, 1996



(Balloon data, Oltmans, private communication, 2000)



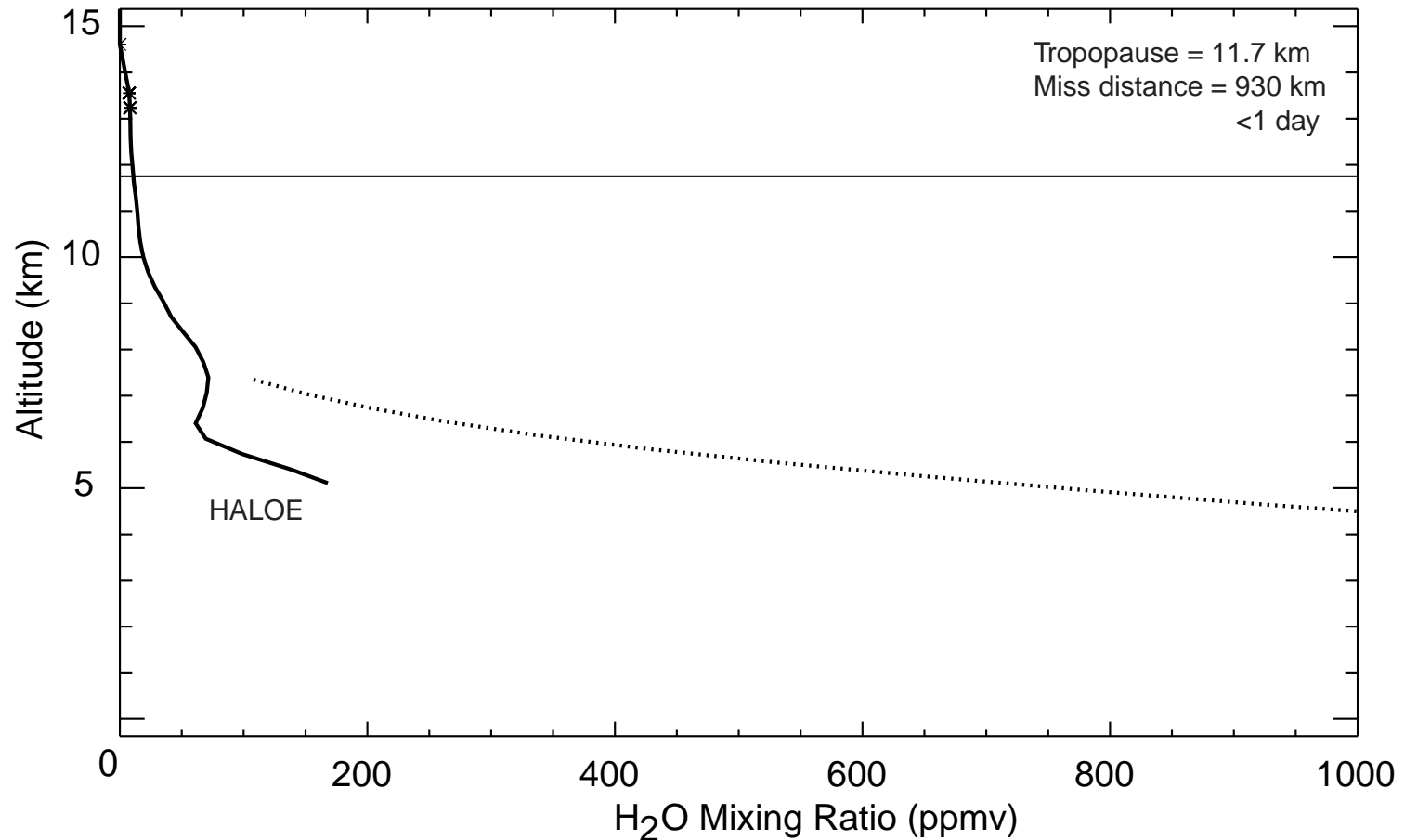
# HALOE upper tropospheric $\text{H}_2\text{O}$ compared with balloon frostpoint hygrometer data, 40°N September 30, 1997



(Balloon data, Oltmans, private communication, 2000)



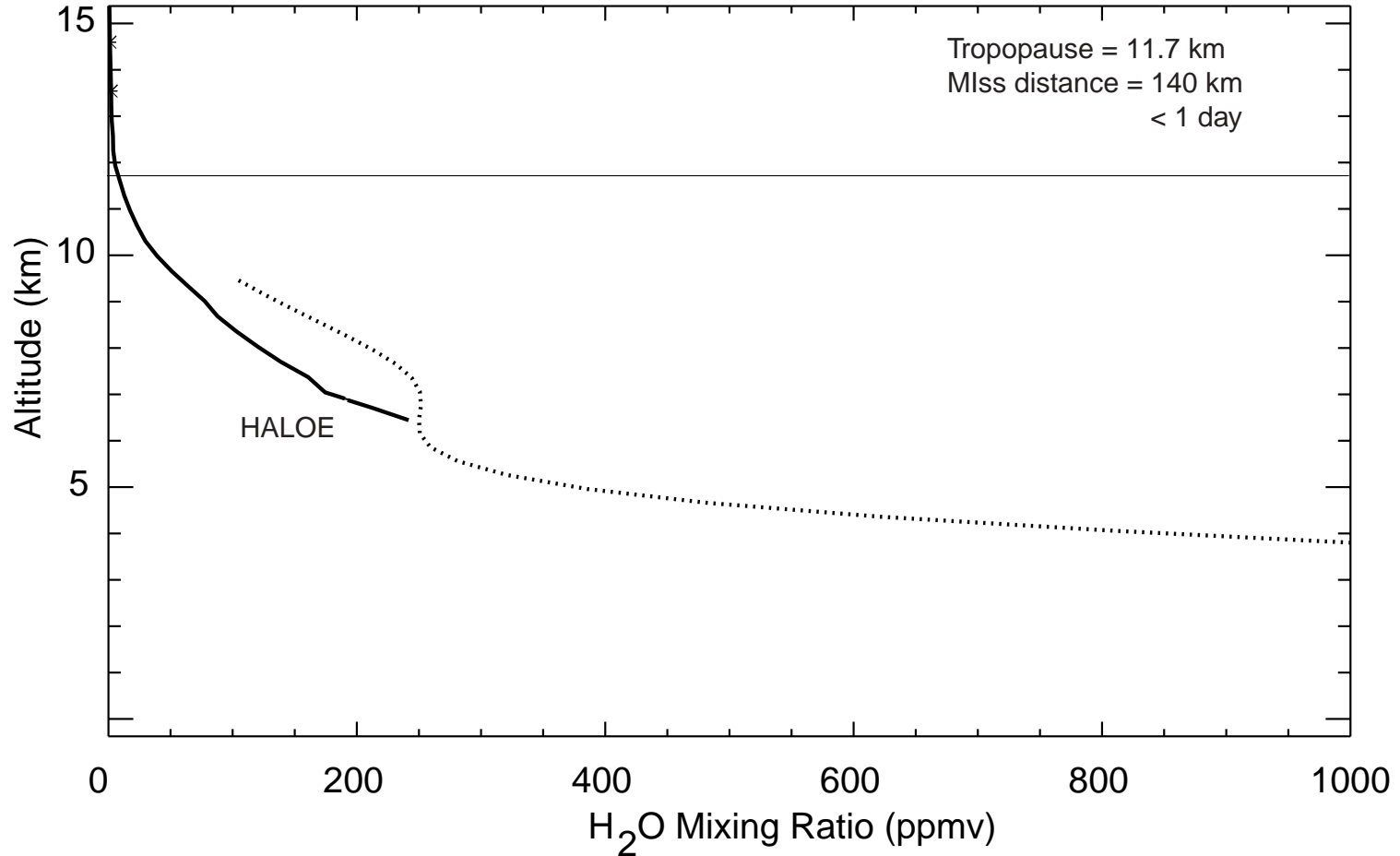
# HALOE upper tropospheric $\text{H}_2\text{O}$ compared with Raman lidar data, 44°N, January 23, 1998



(Sherlock, private communication, 2000)



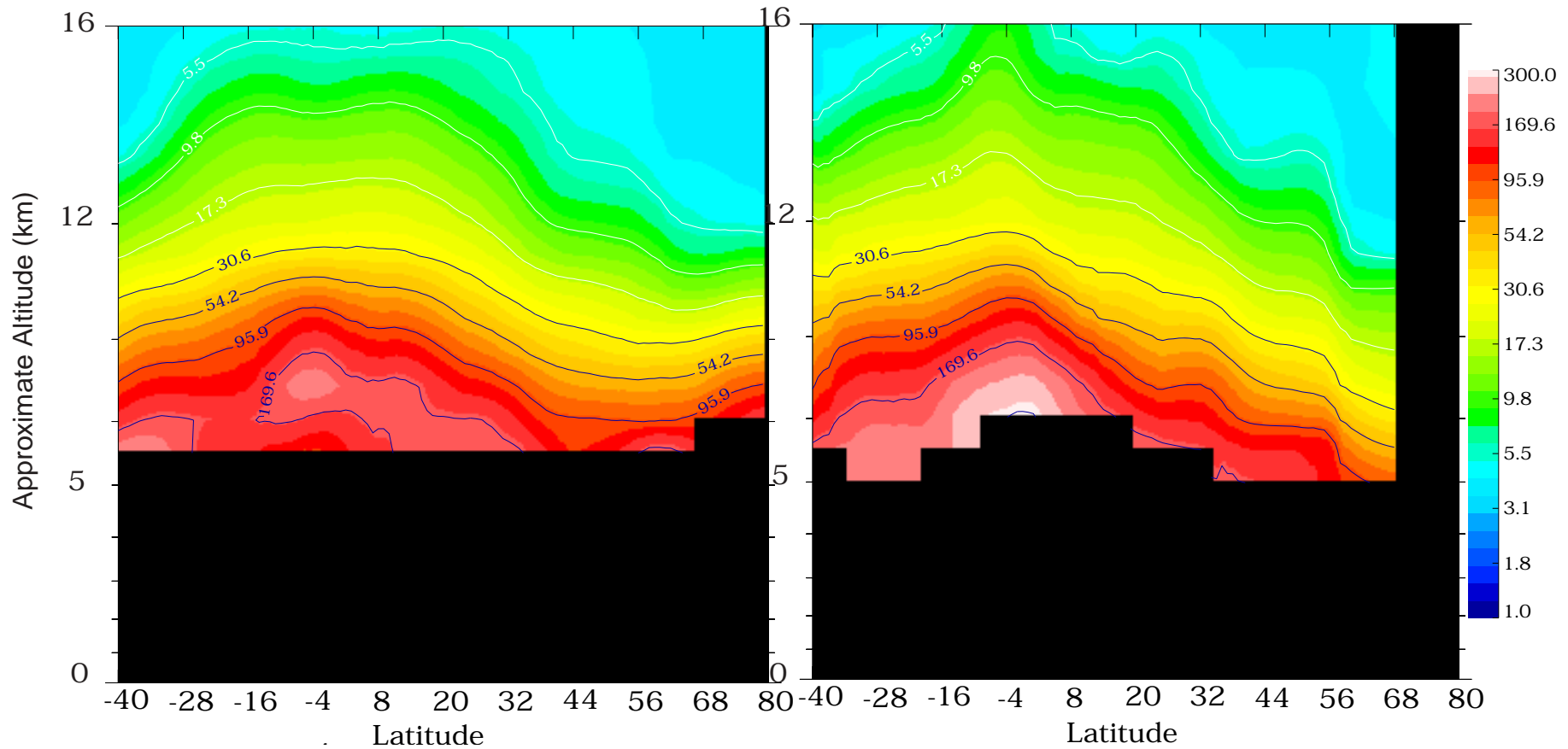
# HALOE upper tropospheric $\text{H}_2\text{O}$ compared with Raman Raman lidar data, 44°N, January 9, 1998



(Sherlock, private communication, 2000)



# HALOE V20 (to be 4<sup>th</sup> Public Release) Tropospheric H<sub>2</sub>O Below 16 km During La Niña and El Niño Events



**La Niña, ( fall/winter 95'- 96' )**

**El Niño, ( fall/winter 97'-98' )**



# HALOE Data Processing Status

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- **Level 0 data has been flowing routinely from PACOR-A computer at the GSFC to the LaRC since November 30, 2001 (*this was when the CDHF stopped processing*)**
- **All data collected from HALOE through ~March, 2003 are processed to Level 2 and available on the HALOE website in netCDF and compressed ASCII formats**

**<http://haloedata.larc.nasa.gov>**

- **ACMAP proposal to process 4<sup>th</sup> Public Release(V20) approved. Processing to begin soon.**



# HALOE Summary



- The absolute science signals have changed  $\leq \sim 2.5\%$  since activation on October 11, 1991 showing excellent experiment stability
- All other indicators show experiment is stable and providing valuable data for long-term change studies
- The HALOE 4<sup>th</sup> Public Release (V20) data processing will begin soon
  - Retrieving tropospheric H<sub>2</sub>O using the HF gas filter channel extends data down to  $\sim 6$  km and reduces sensitivity to aerosols and thin cirrus
  - H<sub>2</sub>O comparisons with balloon frostpoint and ground-based lidar data show reasonable agreement
  - Tropospheric observations will be biased toward dry regions because HALOE cannot “see” through clouds